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# Performance of rice (*Oryza sativa*)-based crop sequences in Central Plains Zone of Uttar Pradesh

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## ABSTRACT

An experiment was conducted during 1998–99, 1999–2000 and 2000–2001, at Regional Research Sub-station Saini, Kaushambi, Uttar Pradesh, to work out suitable and profitable rice (*Oryza sativa* L.)-based crop sequence on sandy-loam soil. The maximum rice-grain-equivalent yield was recorded in rice–chickpea (*Cicer arietinum* L.) + linseed (*Linum usitatissimum* L.)–cucumber (*Cucumis sativus* L.) crops sequence (162.61 q/ha), followed by rice–chickpea + yellow season (*Brassica campestris* var. yellow sarson)–cucumber (161.22 q/ha) and were significantly superior to that of remaining crop sequences. The lowest rice-grain equivalent (111.88 q/ha) was found under rice–chickpea+linseed–mungbean (*Phaseolus radiatus* L.) crop sequence. Production efficiency based on 3 years was found highest with rice–chickpea+linseed–cucumber (50.97 kg/ha/day), followed by rice chickpea+yellow sarson–cucumber (50.54 kg/ha/day). The total monetary gain, returns/ha/day and benefit : cost ratio were recorded maximum with rice–chickpea+linseed–cucumber, followed by rice–chickpea+yellow sarson–cucumber. The maximum land-use efficiency was associated with rice–toria (*Brassica campestris* var. toria)–wheat–cucumber (94.5%).

***Key words:*** Rice-based cropping, Grain equivalent, Land-use efficiency, Production efficiency

Since long, conventional cropping system of rice–wheat is being followed in the most of the areas of Central Plains Zone of Uttar Pradesh. The productivity of rice–wheat system has shown consistently declining trend in most of the areas. However, inclusion of pulses, oilseeds and vegetables in the system was found more beneficial than cereals after cereals (Kumpawat, 2001; Raskar and Bhoi, 2001). Therefore, the selection of crops for sequential multiple cropping based on farmers' needs, the present experiment was conducted to evaluate the performance of rice-based crop sequences for higher production and profit in Central Plains Zone of Uttar Pradesh.

## MATERIALS AND METHODS

A field experiment was conducted in a permanent layout at Regional Research Sub-station, Saini, Kaushambi, Uttar Pradesh, during 1998–99, 1999–2000 and 2000–2001 in randomized block design, replicated thrice with 6 crop sequences, viz. rice–wheat–mungbean ($T_1$), rice–wheat– cucumber ($T_2$), rice–chickpea + linseed–mungbean ($T_3$), rice–chickpea + linseed–cucumber ($T_4$), rice–chickpea + yellow sarson–cucumber ($T_5$) and rice–toria–wheat-cucumber ($T_6$). The soil of experimental field was sandy loam, initially having pH 8.1, organic carbon 0.30%, electrical conductivity 0.25 dS/m, available $P_2O_5$ 19 kg and available $K_2O$ 160 kg/ha. Rice ('Sarjoo 25'), wheat ('PBW 343'), mungbean ('PDM 11'), chickpea ('Awrodhi'), linseed ('Shubhra)' toria ('Bhawani'), yellow sarson (local) and cucumber (local) were used. In treatment $T_6$, wheat variety 'Halna' was planted in the first week of January in every year. For all crops the recommended dose of fertilizer, row spacing, seed rate, intercultural operation and plant-protection measures were followed. Under intercropping treatments (treatments 3,4 and 5), 3 rows of chickpea followed by 1 row of linseed or yellow sarson were planted at 45 cm spaces in furrows. After final picking, crop residue of mungbean and cucumber were ploughed before transplanting of rice. Crop received rainfall 1,100, 757 and 768 mm during crop period of 1998–99, 1999–2000 and 2000–2001 season respectively. The economics of each sequence was computed with minimum support price or prevailing market rate of products.

## RESULTS AND DISCUSSION

### *Crop yield*

On the basis of 3-year result, crop yields were affected due to different crop sequences (Table 1). During 1999–

2000 and 2000–2001 rice and wheat both yielded less yield than the yield of base year (1998–99) under all sequences. It might be due to seasonal variation, low rainfall and crop combinations. Inclusion of mungbean in crop sequences improved the grain yield of rice in comparison to cucumber. Introduction of mungbean of cropping system not only improved the yield of rice but also attributed to less exhaustion of soil fertility and also improved physical properties of the soil to some extent as compared to cucumber. Sharma *et al.* (1986) and Quayyum and Maniruzzaman (1996) also reported that legumes in rotation improve soil fertility and thereby increase the productivity of subsequent non-legume crop.

### Rice-grain-equivalent yield

Pooled data of 3 years revealed that sowing of rice–chickpea+linseed–cucumber and rice–chickpea+yellow sarson–cucumber gave significantly higher rice-grain equivalent than other crop sequences. During 1998–99 rice–wheat–mungbean and rice–chickpea+linseed–mungbean system gave significantly lower-grain-equivalent yield than other tested crop sequences. Remaining sequences were at par among them. However, rice–chickpea + linseed–cucumber, rice–chickpea+yellow sarson–cucumber and rice–wheat–cucumber yielded significantly higher rice-grain equivalent during 1999–2000 over rice–wheat–mungbean, rice–chickpea+linseed–mungbean and rice–*toria*–wheat–cucumber. While rice–chickpea+linseed–cucumber and rice–chickpea+yellow sarson–cucumber were found better and gave significantly higher rice–grain equivalent during 2000–2001.

### Production efficiency

Rice–chickpea+linseed–cucumber crop sequence re-

**Table 1.** Effect of different rice-based crop sequences on grain and straw yields and rice-grain equivalent

| Sequence | Grain yield (q/ha) | | | | Straw yield (q/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | $Y_1$ | $Y_2$ | $Y_3$ | Mean | $Y_1$ | $Y_2$ | $Y_3$ | Mean |
| Rice– | 51.62 | 47.62 | 39.37 | 46.20 | 64.50 | 57.10 | 47.20 | 56.26 |
| Wheat– | 49.29 | 54.50 | 44.35 | 49.38 | 54.20 | 59.95 | 48.79 | 54.31 |
| Mungbean | 5.95 | 7.25 | 2.10 | 5.10 | | | | |
| Rice equivalent | 125.85 | 129.15 | 97.36 | 117.45 | | | | |
| Rice– | 51.87 | 46.62 | 36.25 | 44.91 | 64.80 | 55.90 | 43.50 | 54.73 |
| Wheat– | 49.19 | 53.08 | 43.87 | 48.70 | 54.10 | 58.39 | 48.26 | 53.58 |
| Cucumber | 171.75 | 157.50 | 107.75 | 145.66 | | | | |
| Rice equivalent | 157.21 | 157.66 | 111.30 | 142.04 | | | | |
| Rice– | 51.90 | 47.83 | 39.17 | 46.30 | 64.80 | 57.40 | 47.00 | 56.40 |
| Chickpea + | 16.45 | 19.25 | 22.00 | 19.23 | 11.50 | 13.50 | 15.40 | 13.46 |
| Linseed– | 4.46 | 3.67 | 3.25 | 3.79 | | | | |
| Mungbean | 8.12 | 7.37 | 3.50 | 6.33 | | | | |
| Rice equivalent | 119.20 | 113.62 | 102.83 | 111.88 | | | | |
| Rice– | 52.74 | 46.45 | 36.46 | 45.21 | 65.90 | 55.80 | 43.75 | 55.15 |
| Chickpea+ | 16.70 | 18.62 | 22.93 | 19.41 | 11.70 | 13.00 | 16.05 | 13.58 |
| Linseed– | 4.68 | 3.87 | 3.03 | 3.86 | | | | |
| Cucumber | 236.00 | 250.80 | 201.90 | 229.57 | | | | |
| Rice equivalent | 164.22 | 170.88 | 152.73 | 162.61 | | | | |
| Rice– | 52.20 | 46.75 | 36.67 | 45.20 | 65.25 | 56.10 | 44.00 | 55.11 |
| Chickpea + | 15.54 | 16.87 | 21.82 | 18.07 | 10.89 | 11.81 | 15.27 | 12.65 |
| Yellow sarson– | 6.00 | 3.50 | 2.95 | 4.15 | | | | |
| Cucumber | 233.50 | 257.00 | 210.00 | 233.50 | | | | |
| Rice equivalent | 163.00 | 168.23 | 152.43 | 161.22 | | | | |
| Rice– | 51.17 | 46.12 | 37.92 | 45.07 | 63.95 | 55.30 | 45.50 | 54.91 |
| Toria– | 12.87 | 12.37 | 11.55 | 12.26 | | | | |
| Wheat– | 26.32 | 30.12 | 21.44 | 25.96 | 25.00 | 27.80 | 21.40 | 24.73 |
| Cucumber | 166.00 | 122.66 | 91.85 | 126.84 | | | | |
| Rice equivalent | 157.35 | 147.07 | 117.75 | 140.72 | | | | |
| CD (P=0.05) | 10.17 | 11.70 | 12.39 | 11.89 | | | | |

$Y_1$, 1998–99; $Y_2$, 1999–2000; $Y_3$, 2000–2001

**Table 2.** Production efficiency, land-use efficiency and economics of different crop sequences (pooled data from 1998–99 to 2000–2001)

| Sequence | Production efficiency | | Duration (days) | Land-use efficiency | Net return (Rs/ha/ annum) | Benefit : cost ratio | Sustainability index | |
|---|---|---|---|---|---|---|---|---|
| | kg/ha/ day | Rs/ha/ day | | | | | Yield | Value |
| Rice–wheat–mungbean | 31.66 | 94.95 | 318 | 87.2 | 30,193 | 0.95 | 0.29 | 0.25 |
| Rice–wheat–cucumber | 46.57 | 112.08 | 305 | 83.5 | 34,183 | 0.83 | 0.35 | 0.28 |
| Rice–chickpea+linseed–mungbean | 33.80 | 92.00 | 331 | 90.6 | 30,453 | 1.20 | 0.28 | 0.25 |
| Rice–chickpea + linseed–cucumber | 50.97 | 140.59 | 319 | 87.3 | 44,857 | 1.26 | 0.40 | 0.37 |
| Rice–chickpea + yellow sarson–cucumber | 50.54 | 138.41 | 319 | 87.3 | 44,152 | 1.24 | 0.40 | 0.37 |
| Rice–toria–wheat–cucumber | 40.79 | 68.49 | 345 | 94.5 | 23,630 | 0.50 | 0.35 | 0.20 |
| CD (P=0.05) | | | | | 2,834 | | | |

Minimum support price or prevailing market rate (Rs/q) of produce) : Rice, 450, 490, 510; wheat, 545, 585, 610; chickpea, 1,000, 1,015, 1,100; linseed, 1,100, 1,150, 1,250; sarson, 1,150, 1,100, 1,200; toria, 1,050, 1,100, 1,200; mungbean, 1,100, 1,150, 1,200; cucumber, 120, 150, 150; rice straw, 25, 30, 25; wheat straw 50, 55, 60; and chickpea 30, 30, 35 during 1998–99, 1999–2000 and 2000–2001 respectively

corded greater production efficiency in terms of kg/ha/day (50.97) and Rs/ha/day (140.59). The lowest production efficiency (31.66 kg/ha/day and 68.49 Rs/ha/day) was associated with rice–wheat–mungbean and rice–toria–wheat–cucumber crop sequence respectively. The maximum land-use efficiency (94.5%) was recorded with rice–toria–wheat–cucumber, followed by rice–chickpea + linseed–mungbean (90.6%).

### *Net return*

The 3-year mean value revealed that rice-chickpea + linseed–cucumber gave the highest net return (Rs 44,857/ ha/annum), followed by rice–chickpea+yellow sarson–cucumber (Rs 44,152/ha/annum). The lowest net return (Rs 23,630/ha/annum) was recorded with rice–toria–wheat–cucumber. It might be due to higher cost of production in late wheat cultivation. Rice–chickpea+linseed–cucumber and rice–chickpea+yellow sarson–cucumber gave better returns during experimental years. It might be due to complementary relationship between chickpea and linseed. While yellow sarson being short-duration (100–110 days duration) crop produced less shade effect on chickpea crop. In this system, cucumber also gave higher yield owing to planting at normal time. These results confirm the findings of Pali *et al.* (1997). In general, inclusion of cumcumber in crop sequences improved monetary gain.

### *Benefit : cost ratio*

Highest benefit : cost ratio (1.26) was obtained with rice–chickpea+linseed–cucumber crop sequence, followed by rice–chickpea+yellow sarson–cucumber (1.24). The lowest benefit : cost ratio (0.50) was noted with rice–toria–wheat–cucumber. It may be owing to higher production cost and less market price of the economic produce and at same time low productivity of late wheat and cucumber. In general, intercropping of winter season crops (chickpea with linseed/yellow sarson) enhanced the monetary gain. Singh *et al.* (1992) also observed that intercropping is a potentially beneficial system of crop production and can provide substantial yield advantage over sole cropping.

### *Sustainability of cropping sequence*

The sustainable yield index (SYI) and sustainable value index (SVI) were more with rice–chickpea+linseed or yellow sarson, followed by cucumber (SYI 0.40 and SVI 0.37) in terms of yield and value of products (Table 2).

On the basis of 3 years experimental findings it is concluded that adoption of pulses and oilseeds as companion crop after rice followed by cucumber proved to be the best crop sequence for central plains zone of Uttar Pradesh. These sequences will not only give higher monetary gain but also fulfil the demands of farm families and solve the crisis of cereals, pulses, oilseed and vegetables. Thus farmers may choose any crop sequence which was tested with due consideration of available resources and family needs.

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